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(54) **Method for producing a thin film resistor**

Herstellungsverfahren für einen Dünnschichtwiderstand

Méthode de fabrication d'une résistance à couche mince

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**EP 0 603 782 B1**

**Description****Field of the Invention**

**[0001]** The present invention relates to a method for producing a thin film resistor. More particularly, the invention relates to a thin film resistor which can be used as one for a heating resistor element in a liquid jet head for ejecting ink or the like from a discharge port utilizing the thermal energy.

**Related Background Art**

**[0002]** A thin film resistor is used for example in a liquid jet head for ejecting a liquid such as ink from a discharge port utilizing thermal energy. An example of known layer structure for such a thin film resistor is a lamination in which a heat storage insulating layer, a heating resistor layer, a conductive wiring material layer electrically connected to the heating resistor layer, and an insulating protective layer (passivation film) are consecutively laminated on a silicon substrate.

**[0003]** Fig. 1 is a schematic cross section to show an example of a base for thin film resistor having the above structure. In Fig. 1, reference numeral 101 designates a silicon substrate, 102 a heat storage insulating layer of silicon oxide, 103 a heating resistor layer, 104 a wiring material layer mainly containing aluminum, and 105 an insulating protective layer made of silicon oxide, which constitute a base 100 for thin film resistor.

**[0004]** The etching process has been used heretofore for forming a patterning of aluminum wiring electrodes in a desired layout.

**[0005]** An example of patterning formation is described below referring to schematic cross sections shown in Figs. 2A to 2C.

**[0006]** First prepared is a lamination, which was formed by consecutively laminating the heat storage layer 102, the heating resistor layer 103 and the electrode material layer 104 on the substrate 101 by the sputtering method or the CVD method in a film-forming apparatus. Then, positive photoresist 106 (for example OFPR-800 supplied by TOKYO OHKA KOGYO CO., LTD.) is applied in a desired thickness (for example 2  $\mu\text{m}$ ) to the surface of the wiring material layer 104, for example, of Al deposited over the entire upper surface of the lamination. After that, patterning is carried out for forming electrodes under irradiation of light (Fig. 2A). Subsequently, exposed portions of the wiring material layer 104 are etched with an etchant (etching solution), for example an acid aqueous solution containing phosphoric acid ( $\text{H}_3\text{PO}_4$ ), nitric acid ( $\text{HNO}_3$ ) and acetic acid ( $\text{CH}_3\text{COOH}$ ) (Fig. 2B). Then the positive photoresist 106 after patterning is removed for example by the  $\text{O}_2$  ashing method.

**[0007]** According to EP-A-0 518 467, an aqueous alkaline solution containing 2.38% of tetramethylammonium hydroxide can be used as the etching solution.

**[0008]** According to these steps, electrodes are formed at desired intervals on the heating resistor layer 103. The insulating protective layer is thereafter formed by depositing an insulating layer such as  $\text{SiO}_2$  in the film-forming apparatus.

**[0009]** The heating resistor heats, because the heating resistor layer 103 between electrodes heats when a current is supplied to the wiring electrode layer 104.

**[0010]** The film-forming apparatus has a film-forming chamber, in which the thin film resistor having the above-described film layer structure is produced. As the film formation is repetitively carried out in the film-forming chamber, a film-forming material is likely to be deposited to form a film thereof not only on the substrate but also on the wall of the film-forming chamber. When this film deposited on the wall has a film thickness exceeding a certain level, film exfoliation occurs due to a difference in thermal expansion coefficient from the wall of film-forming chamber or due to membrane stress of the film itself, causing defects such as pinhole on device (resistor), and in turn resulting in lowering the yield. Therefore, the interior of film-forming chamber must be cleaned before the film exfoliation starts. For example, in case of  $\text{SiO}_2$ , cleaning is necessary normally before the cumulative film thickness reaches 50  $\mu\text{m}$ .

**[0011]** In some cases, the film-forming apparatus is provided with an anti-sticking plate as anti-sticking means therein in order to reduce or prevent the deposition of film-forming material in undesired portions inside the apparatus.

**[0012]** In more detail, the wall surface of film-forming chamber is covered by a plate of aluminum or stainless steel and the anti-sticking plate is changed for another when the cleaning (removal of deposited film) is necessary on the wall surface of film-forming chamber, whereby the cleaning could be simplified.

**[0013]** However, the acid also etches the heating resistor layer 103 in the above-described example for producing a resistor, that is, the heating resistor layer 103 ( $\text{HfB}_2$ ) is etched, and a value of resistance of resistor changes. The change in resistance could arise problems such as a drop of yield or lowering of reliability of thin film resistor.

**[0014]** Meantime, to change the anti-sticking plate in film-forming apparatus for another, vacuum in the film-forming chamber is inevitably broken and a lot of time is necessary for re-starting the film-forming apparatus after the exchange of plates. Thus, such a method had various problems, for example a drop of operating efficiency of apparatus, a longer

evacuation time after the interior of film-forming apparatus is exposed to the atmospheric pressure for a long time, which causes water or gas to stick thereto, or an unstable film-forming speed due to residual gas. In contrast, if the cleaning frequency is lowered, the yield is dropped due to particles (dust), which was another problem.

## SUMMARY OF THE INVENTION

**[0015]** The present invention has been accomplished taking the above problems into account. It is an object of the present invention to provide a method for producing a thin film resistor, which can avoid unnecessary etching of heating resistor layer so as to cause no or little change in resistance of thin film resistor and to improve the yield and the reliability of thin film resistor.

**[0016]** It is another object of the present invention to provide a method for producing a thin film resistor, which can readily produce a thin film resistor as designed having stable heating properties, so that a liquid jet head having the thin film resistor can have stable ejection properties and high reliability.

**[0017]** It is another object of the present invention to provide a method for producing a thin film resistor, said thin film resistor comprising a wiring material formed on a heating resistor material and said wiring material being a material containing aluminum as a main component, which has a step of etching the wiring material so as to perform patterning in a desired layout, wherein the wiring material is etched by an alkaline aqueous solution.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0018]**

Fig. 1 is a schematic cross section to illustrate an example of a base for a thin film resistor;

Figs. 2A to 2C are schematic cross sections to illustrate an example of a method for producing a base for a conventional thin film resistor;

Figs. 3A to 3C are schematic cross sections to illustrate an example of a method for producing a base for a thin film resistor according to the present invention;

Figs. 4A to 4C are schematic cross sections to illustrate another example of a method for producing a base for a thin film resistor not according to the present invention;

Figs. 5A to 5D are schematic cross sections to illustrate another example of a method for producing a base for a thin film resistor according to the present invention;

Fig. 6 is a schematic perspective view to illustrate an example of an ink jet recording head to which the thin film resistor of the present invention can be applied;

Fig. 7 is a schematic perspective view to illustrate an example of a recording portion using the ink jet recording method, to which the thin film resistor of the present invention can be applied;

Fig. 8 is a block diagram to illustrate an example of construction of an information processing apparatus to which the recording head of the present invention is applied;

Fig. 9 is a schematic perspective view to show an example of a recording portion using the ink jet recording method, to which the information processing apparatus of the present invention can be applied;

Figs. 10A and 10B, Figs. 12A and 12B, Figs. 13A and 13B, and Figs. 15A to 15C are schematic illustrations respectively to illustrate an antisticking means and a film-forming apparatus which may be used according to the present invention; and

Fig. 11 and Fig. 14 are graphs to show test results for explaining the effect of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0019]** The embodiments of the present invention will be described with reference to the accompanying drawings with necessity.

**[0020]** The method for producing a thin film resistor according to the present invention is defined by the features of claims 1 or 2, respectively. For achieving the above objects, the method employs an etchant of alkaline aqueous solution as an etchant for etching a wiring material.

**[0021]** This can avoid unnecessary etching of the heating resistor layer so as to effect patterning only on the wiring material in a desired layout.

**[0022]** In this case, the wiring material is aluminum or an alloy containing aluminum as a main component. In case of the alloy containing aluminum as a main component, aluminum is contained preferably in an amount of at least 70 % by weight, more preferably in an amount of at least 80 % by weight, or further more preferably in an amount of at least 93 % by weight. This rate may be changed with necessity depending upon the properties of etchant to be used.

**[0023]** In the present invention, the material for resistor may be any material which can be etched by an acid aqueous

solution but cannot be etched by an alkaline aqueous solution. The material may be hafnium, zirconium, nickel, gold, silver, iron, palladium, silicon, tantalum, titanium, niobium, cobalt, indium, alloys thereof or compounds containing them, for example, hafnium boride, zirconium boride, tantalum nitride, tantalum aluminum.

[0024] The anti-sticking means useful in the present invention has a tongued-and-grooved pattern on the surface thereof. This pattern forms continuous portions in shadow as seen at a target or evaporation source, on the anti-sticking plate, whereby a film is deposited on the anti-sticking plate in a discontinuous manner (with no film stuck to the shadow portions), thereby relaxing the membrane stress and then delaying the time of start of film exfoliation. The tongued-and-grooved pattern is preferably formed normally at pitch in the range of about 1 to 50 mm on the surface of anti-sticking plate.

[0025] In the present invention, the expression that a deposited film is discontinuous includes that a film is interrupted, if partially, or the anti-sticking means or the film-forming chamber wall appears, but the term of "continuous" represents that a deposited film is substantially formed all over the surface with uninterrupted.

[0026] Also, an anti-sticking plate for film-forming apparatus such as sputtering apparatus or vapor-deposition apparatus can be used, which can keep the yield from dropping due to particles even with lowered frequency of cleaning of the filmforming chamber.

[0027] Incidentally, the sputtering (as shown in Fig. 10A) is such a phenomenon that when accelerated high-energy particles 5 are made to collide with the target 6, atoms or molecules in the target exchange momentum with the high-energy particles so as to be released into the space (as target atoms or molecules 4).

[0028] The sputtering apparatus is an apparatus utilizing this phenomenon to perform film formation by depositing a thin film on a substrate. When a film is formed using the sputtering apparatus, a film-forming material is deposited not only on the substrate but also on the anti-sticking plate substantially in the same film thickness. For example, in case of  $\text{SiO}_2$ , assuming a film is formed in thickness of 1  $\mu\text{m}$  per cycle, the anti-sticking plate must be changed for another before 50 cycles (before the cumulative film thickness exceeds 50  $\mu\text{m}$ ) but the present invention can extend the exchange timing.

[0029] The vapor-deposition apparatus (as shown in Fig. 13A) forms a film such that a metal or insulator (evaporation source) 9 is heated in vacuum (by resistive heating element 11) and that thus evaporating particles are made to be deposited on the substrate 10. The method is the vapor-deposition method and the apparatus is the vapor-deposition apparatus.

[0030] The vapor-deposition apparatus may employ the same structure for the anti-sticking plate in film-forming chamber as in the sputtering apparatus, in which discontinuous portions are provided on the anti-sticking plate as being in shadow as seen at the evaporation source. Then a film is deposited on the anti-sticking plate in a discontinuous manner, which can relax the membrane stress and delay the start timing of film exfoliation.

[0031] Now, the present invention will be further described in detail with various examples, but it should be noted that the present invention is not intended to be limited to the examples. Example 2 is not an embodiment of the invention, but is useful for its understanding.

#### Example 1

[0032] Figs. 3A to 3C are schematic cross sections to show a method for producing a wiring part in a base for recording head according to the present invention. In Figs. 3A to 3C, reference numeral 200 denotes a part of the base for recording head and 101 to 104 are the same as those as shown in common in Figs. 2A to 2C, 3A to 3C, and 4A to 4C.

[0033] In Figs. 3A to 3C, the recording head base 200 was formed such that a film of silicon oxide was formed as a heat storage layer 102 on a substrate 101 by the thermal oxidation, the CVD (vapor-deposition) method or the sputtering method and thereafter hafnium boride ( $\text{HfB}_2$ ) and aluminum (Al) were consecutively deposited on the heat storage layer 102 by sputtering or vapor deposition to form a heating resistor layer 103 of  $\text{HfB}_2$  and a wiring electrode layer 104 of Al, respectively.

[0034] Then utilizing the photolithography technology, the Al layer 104 deposited over the entire surface was coated by a negative photoresist 105 (for example OMR-83 supplied from TOKYO OHKA KOGYO CO., LTD.) in thickness of 1  $\mu\text{m}$  and patterning was carried out for forming electrodes (see Fig. 3A). The reason why the negative photoresist is used herein is that a positive resist could dissolve in some of alkaline aqueous solutions before etching is completed.

[0035] Then the Al layer 104 was etched by an alkaline aqueous solution (for example alkaline aqueous solution containing KOH, NaOH or ethylenediamine) (see Fig. 3B). In this case, over etching did not result in etching  $\text{HfB}_2$  of the ground heating resistor layer 103. Subsequently, the negative photoresist 105 was removed by the  $\text{O}_2$  ashing for example (see Fig. 3C).

[0036] As described above, etching the Al layer 104 using the alkaline aqueous solution, only the Al layer was selectively etched independent of  $\text{HfB}_2$  of ground heating resistor layer 103. Table 1 shows Al etching rate and selectivity to  $\text{HfB}_2$  for each case of etching with the alkaline aqueous solution containing KOH and etching with the conventional acidic aqueous solution.

TABLE 1

Etchant	Al Etch Rate	Selectivity to $\text{HfB}_2$
Alkaline Aq. Sol. containing KOH	240 nm/min	○
Acidic Aq. Sol. ( $\text{H}_3\text{PO}_4 + \text{HNO}_3 + \text{CH}_3\text{COOH}$ )	259 nm/min	×

- \* Selectivity: O-selectivity, yes; x-selectivity, no (i.e.,  $\text{HfB}_2$  is etched)
- \* Temperature of solution: 23 °C in case of alkaline aqueous solution; 40 °C in case of acidic aqueous solution
- \* KOH was a 40 % aqueous solution thereof.

**[0037]** A recording head was produced by use of the base produced according to the above steps and subjected to recording tests. The test results showed that such a recording head was able to perform stable ejection of ink for a long duration.

#### Example 2

**[0038]** Figs. 4A to 4C are schematic cross sections to illustrate another example of the method for producing a base for recording head according to the present invention. A part 200 of base for recording head used the same as the base in Example 1 (Figs. 3A to 3C). Utilizing the photolithography technology, the part 200 of recording head base was coated by a positive photoresist 106 (for example OFPR-800 supplied from TOKYO OHKA KOGYO CO., LTD.) in thickness of 2  $\mu\text{m}$  on the Al layer 104 deposited over the entire surface of base, and patterning was carried out for formation of wiring and electrodes (see Fig. 4A).

**[0039]** Then the Al layer 104 was etched by a 2.38 % aqueous solution of tetramethylammonium hydroxide (see Fig. 4B). This aqueous solution can be used as a developer for the photoresist, so that the positive resist does not dissolve therein even if the etchant is an alkaline aqueous solution. Also, when the etchant is used as a developer for photoresist, development of resist can be effected at the same time as the etching of Al, obtaining tapered edges of Al layer and thereby improving coverage property of the protective film.

**[0040]** It should be carefully controlled that tetramethylammonium hydroxide is kept up to 3.5 %, because the resist could dissolve therein in concentration of above 3.5 %. Also, in this case, over etching did not result in etching  $\text{HfB}_2$  of ground heating resistor layer 103. Then the positive photoresist 106 may be well removed for example by the  $\text{O}_2$  ashing (see Fig. 4C).

**[0041]** As described above, the Al layer 104 was also able to be etched using the tetramethylammonium hydroxide aqueous solution which was an alkaline aqueous solution, while only the Al layer was selectively etched independent of  $\text{HfB}_2$  of ground heating resistor layer 103. Table 2 shows an etch rate of Al and a selectivity to  $\text{HfB}_2$  for each case of etching with the etchant in this example and etching with the conventional acidic aqueous solution.

TABLE 2

Etchant	Al Etch Rate	Selectivity to $\text{HfB}_2$
2.38 % Aq. Sol. of Tetramethylammonium hydroxide	70 nm/min	○
Acidic Aq. Sol. ( $\text{H}_3\text{PO}_4 + \text{HNO}_3 + \text{CH}_3\text{COOH}$ )	259 nm/min	×

- \* Selectivity: O-selectivity, yes; x-selectivity, no (i.e.,  $\text{HfB}_2$  is etched)
- \* Temperature of solution: 40 °C for the developer and for the acidic aqueous solution

**[0042]** A recording head was produced by use of the base thus produced in this example and subjected to a drive test.

**[0043]** The test results showed that the recording head was able to perform stable recording for a long duration.

#### Example 3

**[0044]** Figs. 5A to 5D are schematic cross sections to illustrate still another example of the method for producing the base for recording head according to the present invention. A part 200 of base for recording head was the same as used in Example 1 (Figs. 3A to 3C). Using the photolithography technology, the part 200 of recording head base was coated by a positive photoresist 106 in thickness of 2  $\mu\text{m}$  on the Al layer 104 deposited over the entire surface of base, and patterning was carried out for forming electrodes (see Fig. 5A).

**[0045]** Then the Al layer 104 was etched half by an etchant for Al (acidic aqueous solution) (see Fig. 5B). The reason

why the Al layer was first half-etched is that a tetramethylammonium hydroxide aqueous solution for next process has a slow etch rate of Al, which drops processing rate, and therefore that the drop in processing capability is compensated for by the half etching of Al with the acidic aqueous solution having a faster etch rate of Al.

[0046] Then the Al layer 104 was completely etched by 2.38 % aqueous solution of tetramethylammonium hydroxide (see Fig. 5C). Further, the positive photoresist 106 was removed by the O<sub>2</sub> ashing for example (see Fig. 5D).

[0047] Although this etching method has a slower processing speed than the etching in Example 1 only with the alkaline aqueous solution, it has better coverage of protective film because of the tapered upper edges of Al layer. Also, in case the alkaline aqueous solution with slower etching rate of Al is used as in Example 2, the half etching with acid aqueous solution is effective.

[0048] In the above process, the Al layer 104 was etched half by the acidic aqueous solution and thereafter further half by the tetramethylammonium hydroxide aqueous solution which was the alkaline aqueous solution, whereby only the Al layer was able to be selectively etched without etching the HfB<sub>2</sub> of heating resistor layer 103, that is, independent of HfB<sub>2</sub>.

#### Example 4

[0049] Liquid jet heads were produced by use of the methods for producing the thin film resistor as described above with Examples 1 to 3, and properties thereof were investigated.

[0050] First described are the structure and the principle of a liquid jet head employed in this example. The structure and the principle are preferably based on the basic principle as disclosed for example in United States Patent No. 4723129 or No. 4740796. This method can be applicable to either of so-called on-demand type and continuous type. This method is suitable in particular for cases of on-demand type, because the overall apparatus can be constructed in a compact size.

[0051] This method is briefly described in the following. An electrothermal converter is arranged in correspondence with a sheet or a liquid conduit in which a liquid (ink) is kept. The electrothermal converter generates thermal energy when at least one drive signal corresponding to recording information, which can cause a rapid temperature rise over the nuclear boiling, is applied to the electrothermal converter. This thermal energy causes film boiling on the thermal action surface of the liquid jet head (as will be referred to as "recording head"), resulting in forming a gas bubble in the liquid in one-to-one correspondence with the recording signal. The liquid is ejected through a discharge opening upon growth and constriction of this bubble so as to form at least one drop. Employing a pulse signal as the drive signal, the growth and constriction of bubble can be made quickly and properly, so that the liquid ejection excellent especially in responsibility can be achieved, which is more preferable.

[0052] The pulse drive signal is preferably one as described in United States Patent No. 4463359 or No. 4345262. More excellent recording can be carried out employing the conditions as described in United States Patent No. 4313124 disclosing the invention concerning the temperature rise rate of the above thermal action surface.

[0053] The construction of recording head may be one as described in United States Patent No. 4558333 or No. 4459600 each disclosing the arrangement in which the thermal action surface is set in a bent region, as well as the constructions of combination of discharge port, liquid conduit and electrothermal converter (including a linear liquid conduit or liquid conduit having a bent portion) as described in the specifications of the patents as listed above. In addition, a plurality of electrothermal converters may be effectively constructed employing the construction based on Japanese Laid-open Patent Application No. 59-123670 disclosing the arrangement of a common slit as a discharge portion of liquid or Japanese Laid-open Patent Application No. 59-138461 disclosing the arrangement in which an aperture for absorbing pressure waves of thermal energy is employed as a discharge portion.

[0054] Further, the recording head may be one of full-line type having a length corresponding to the maximum width of recording medium in which the recording apparatus can perform recording. In this case, the length may be attained by combining a plurality of recording heads as described in the above specifications or by a single recording head integrally formed.

[0055] Additionally, a preferable recording head may be one of an interchangeable chip type which, upon mounting onto the main body of apparatus, can be electrically connected to the main body of apparatus and can receive supply of ink from the main body of apparatus, or one of a cartridge type in which electrical connections and an ink tank are integrally incorporated.

[0056] Also, recovery means or preliminary helping means may be preferably added to the recording head as a component in an information processing apparatus according to the present invention, thereby making the apparatus further free in maintenance.

[0057] Specifically, effective means for stable recording, added to the recording head, is capping means, cleaning means, pressurizing or sucking means, warming means for warming the recording head, such as the electrothermal converter, or a pre-ejecting mode for different ejection from recording.

[0058] Further, the recording mode may be one with only a main color such as black, or one with multicolors or full

colors different from each other, using an integral recording head or a combination of plural recording heads.

[0059] Although the above description concerns only the examples using the liquid (ink), the ink may be a solid ink at room temperature or ink softening at room temperature. Since the above ink jet method is generally carried out under such a temperature control that the ink itself is adjusted in the temperature range of 30 °C to 70 °C to keep the viscosity of ink in a stable ejection range, any ink may be employed as long as it is in a liquid state upon application of recording signal employed. In addition, the ink may be one turning from a solid state to a liquid state with a temperature rise caused by positively supplying thermal energy.

[0060] Next described briefly is an ink jet recording head used in the recording method to eject a liquid by utilizing the thermal energy as described.

[0061] Fig. 6 is a schematic drawing of construction to illustrate an example of an ink jet recording head of such a type. Fig. 6 shows an ink jet recording head composed of electrothermal converters 1103, electrodes 1104, liquid conduit walls 1105 and a top plate 1106, which are formed on a substrate 1102 through the semiconductor fabrication process such as the etching, the vapor deposition, the sputtering and the like. A liquid 1112 for recording is supplied from an unrepresented liquid storage tank to a common liquid chamber 1108 in the recording head 1101 through a liquid supply tube 1107. In Fig. 6, numeral 1109 denotes a connector for the liquid supply tube.

[0062] The liquid 1112 supplied into the common chamber 1108 is then supplied into each liquid conduit 1110 by the so-called capillarity, and kept therein as forming a meniscus on the surface of discharge port (orifice) at the distal end of each liquid conduit. When a current is supplied to an electrothermal converter 1103 in this state, the liquid is steeply heated on the electrothermal converter to form a bubble in a liquid conduit. Inflation and contraction of the bubble ejects the liquid from a discharge port 1111 to form a liquid drop.

[0063] The above arrangement permits discharge ports to be aligned at a high density over 16 nozzles/mm. Therefore, an ink jet head may have 128 discharge ports or 256 discharge ports at such high density. Further, the above arrangement permits an ink jet head of full-line type in which discharge ports are aligned along the entire recording width at the high density.

[0064] Fig. 7 is a perspective view to show the scheme of external construction of the output portion using the ink jet recording method.

[0065] In Fig. 7, 1801 is an ink jet recording head (hereinafter referred to as a recording head) for ejecting ink based on a predetermined recording signal to record a desired image, and 1802 a carriage for scan-moving the recording head 1801 in the recording direction (in the main scanning direction). The carriage 1802 is slidably supported by guide shafts 1803, 1804 so as to reciprocate in the main scanning direction in synchronism with a timing belt 1808. The timing belt 1808 is engaged with pulleys 1806, 1807 and is driven by a carriage motor 1805 through the pulley 1807.

[0066] A recording sheet 1809 is guided by a paper pan 1810 and is carried by an unrepresented sheet-feed roller in press contact with a pinch roller.

[0067] This carriage is carried out by a sheet-feed motor 1816 as a drive source. The conveyed recording sheet 1809 is under a tension between a discharge roller 1803 and a spur 1814 and is further conveyed as kept in close fit with a heater 1811 by a sheet press plate 1812 made of an elastic material. The recording head 1801 ejects ink onto the recording sheet 1809, and the recording sheet 1809 with ink sticking thereto is heated by the heater 1811, whereby the sticking ink is fixed on the recording sheet 1809 by evaporation of water therein.

[0068] Numeral 1815 denotes a unit as called as a recovery system, which removes foreign materials or ink with increasing viscosity sticking to the discharge ports (not shown) in the recording head 1801 so as to maintain the ejection properties in a normal condition.

[0069] Numeral 1818a is a cap constituting a part of the recovery system unit 1815, which caps the discharge ports in the recording head 1801 to prevent occurrence of plugging. An ink absorber 1818 is preferably set inside the cap 1818a.

[0070] Also, a blade 1817 is provided on the recording region side of the recovery system unit 1815 in order to clean foreign materials or ink sticking to the surface of discharge ports while contacting with the surface in which the discharge ports are formed in the recording head 1801.

[0071] In the present invention, recording is carried out as shown in the block diagram in Fig. 8. A photoelectric converter reads image information in the form of electric signals. An image processor converts the thus read electric signals carrying the image information into electric signals for recording. A controller such as CPU (central processing unit) controls the carriage motor, the sheet-feed motor, the recovery system and other elements to carry out recording.

[0072] The electric signals carrying the image information may be transmitted through a communication means to another image processor to be output therefrom, or information may be received from another information processor through the communication means to carry out recording by the above recording head.

[0073] In this example, recording heads were produced using the parts 200 of base produced in Examples 1-3 with 128 discharge ports at setup density of 16 nozzles/mm. Continuous ejection was carried out for each of the recording heads.

[0074] The test results showed no significant difference in ejection properties between discharge ports or between

the recording heads in either one of the recording heads using the parts 200 of base. Also, all the recording heads using the parts of base obtained in the examples were able to perform stable recording for a long duration.

[0075] Next shown in Fig. 9 is the scheme of an output portion in case of a recording head 1932 of full-line type being mounted.

[0076] In Fig. 9, 1965 represents a conveying belt for conveying a recording medium, which conveys an unrepresented recording medium with rotation of a convey roller 1964. The bottom surface of recording head 1932 is a discharge port surface 1931 in which a plurality of discharge ports are aligned corresponding to a recording region on the recording medium.

[0077] Excellent recording was made also in this case similarly as in the case of serial type as described before.

[0078] In the present invention, the alkaline aqueous solution is an aqueous solution containing at least one substance selected from KOH, NaOH, and ethylenediamine, or tetramethylammonium hydroxide, as described before, and in addition a pH controller or a surfactant may be of course added thereto, if necessary.

#### Example 5

[0079] Fig. 10A schematically shows a sputtering apparatus as a vacuum film-forming apparatus equipped with an anti-sticking plate being the anti-sticking means for film-forming apparatus according to an embodiment of the present invention. In this drawing, 1 represents a substrate, 2 is a film-forming apparatus wall, 3 is an anti-sticking plate, 4 is a flying direction of target atom or molecule, 5 is a flying direction of high-energy particles, and 6 represents a target. As shown in Fig. 10A, the anti-sticking plate 3 of this example has a sawtooth cross section. In this example, a test was conducted with a film-forming apparatus in which an anti-sticking plate 3 was arranged around the side face and a substrate 1. Fig. 10B is a partially enlarged cross section for illustrating the deposition of film on the anti-sticking plate 3. Numeral 7 denotes a film-forming material deposited on the anti-sticking plate 3. As shown in Fig. 11, production of particles was remarkably reduced in sputtering by use of a film-forming apparatus equipped with an anti-sticking plate 3 having a sawtooth cross section as compared with to film formation with a normal anti-sticking plate having no tongued-and-grooved pattern.

#### Example 6

[0080] Fig. 12A shows a sputtering apparatus similar to the above, in which an anti-sticking plate has a tongued-and-grooved pattern in rectangular cross section different from that in Fig. 10A. The purpose of the pattern is the same as that in Example 5. Fig. 12B is a partially enlarged cross section of the anti-sticking plate to show a state of film deposition, in which numeral 8 designates a film-forming material deposited thereon. The same numerals in Figs. 12A and 12B as those in Figs. 10A and 10B represent the same as in Figs. 10A and 10B. As shown in Fig. 11, with the anti-sticking plate of rectangular cross section, very stable film formation was made as the production of particles did not steeply increase even with an increase in film thickness.

#### Example 7

[0081] Fig. 13A schematically shows a cross section of a vapor-deposition apparatus as a vacuum film-forming apparatus equipped with an anti-sticking plate being the anti-sticking means for film-forming apparatus according to an embodiment of the present invention. In this drawing, 9 is an evaporation source, 10 is a substrate, 11 is a heating means and 12 is a wall of film-forming chamber. As shown in Fig. 13A, the anti-sticking plate 3 in this example has a rectangular cross section. In this example, a test was conducted with a film-forming apparatus in which an anti-sticking plate 3 was arranged around the side face of film-forming apparatus and a substrate 10. Fig. 13B is a partially enlarged cross section for illustrating the deposition of film on the anti-sticking plate 3. Numeral 13 denotes a film-forming material deposited on the anti-sticking plate 3.

[0082] Fig. 14 shows the result of film formation with an apparatus having the anti-sticking plate. As shown in Fig. 14, only a very small amount of particles were produced with an increase in film thickness in film formation with the anti-sticking plate in this example.

#### Example 8

[0083] Fig. 15A schematically shows a cross section of a vapor-deposition apparatus as a vacuum film-forming apparatus equipped with an anti-sticking plate being the anti-sticking means for film-forming apparatus according to an embodiment of the present invention. Numerals 3a and 3b represent anti-sticking plates, respectively. This example used the combination of the anti-sticking plate 3a having a rectangular cross section and the anti-sticking plate 3b having a sawtooth cross section. Figs. 15B and 15C are partially enlarged cross sections for illustrating the deposition



of films on the anti-sticking plates 3a and 3b, respectively. Numerals 14 and 15 denote film-forming materials deposited on the anti-sticking plates 3a and 3b, respectively. In this example, the anti-sticking plate 3a having a rectangular cross section was arranged around the substrate and the anti-sticking plate 3b having a sawtooth cross section was arranged on the side wall of film-forming chamber.

[0084] It is possible to reduce further the production of particles by changing the cross-section of the anti-sticking plates and the location thereof.

[0085] Fig. 14 shows the result of film formation with an apparatus having the anti-sticking plates as described above. As shown in Fig. 14, with the anti-sticking plates the production of particles was very low with an increase in film thickness.

#### Example 9

[0086] Using the film-forming apparatus with either of the anti-sticking means as described in Examples 5-8, the heating resistor layer ( $\text{HfB}_2$ ), the wiring material (Al) and the insulating protective layer ( $\text{SiO}_2$ ) were formed and recording heads similar to those described in Example 4 were prepared. The recording properties of the recording heads were tested. In the test, no ejection trouble caused by particles was found.

[0087] Further, in case the methods as shown in Examples 1-3 were used for etching of the wiring material, obtained were recording heads excellent in ejection properties and in durability.

[0088] The following advantages can be attained if the wiring electrode layer containing aluminum as a main component is etched by the alkaline aqueous solution as described above. Since the resistor layer remains unetched, a resistor has a less change in resistance, the yield is improved, the productivity is also improved, and the reliability of thin film resistor is raised.

[0089] Also, by making discontinuous the film-forming material, which is deposited on the anti-sticking plate in the film-forming chamber of the film-forming apparatus, the start time of film exfoliation can be delayed, which extends the cycle of cleaning for the anti-sticking plate (by about 33 % in case of the sputtering apparatus and by about 60 % in case of the vapor-deposition apparatus). The elongated cleaning cycle results in reducing the drop in yield due to the film exfoliation.

[0090] Incidentally, each slant face of sawtooth depends upon an apparatus. The each slant face may be on the upper face side or on the lower face side. The slant face is preferably on the substrate side from the viewpoints of easiness in breaking the deposit away from the anti-sticking plate (on the interior surface of apparatus) and of easiness in stop of exfoliating particles.

[0091] It should be noted that the present invention is not limited to the above examples but many modifications can be considered within the scope of the invention as defined by the claims.

[0092] An Al layer of wiring material is etched using the above alkaline aqueous solution. There are provided a method for producing a thin film resistor, in which only the Al layer can be selectively etched independent of a resistor layer using the alkaline aqueous solution. An anti-sticking means for film-forming apparatus having the structure which can prevent a drop in yield due to particles, even with less frequency of cleaning for a film-forming chamber, and a film-forming apparatus provided with the anti-sticking means can suitably be used. When the wiring electrode layer mainly containing Al is etched by the alkaline aqueous solution, only the Al layer can be selectively etched without etching the resistor layer, which can reduce a change in resistance of resistor, improve the yield and the productivity, and raise the reliability of the thin film resistor.

[0093] Also, when the anti-sticking means having a tongued-and-grooved surface is set in the film-forming chamber of the film-forming apparatus, the film-forming material is deposited in a discontinuous manner on the anti-sticking means, which can delay the time of film exfoliation, in turn extend the cycle of cleaning for the anti-sticking plate, and prevent the drop in yield due to the film exfoliation.

#### Claims

1. A method of producing a thin film resistor, in which the thin film resistor has a wiring material (104) formed on a heating resistor material (102), in which said wiring material is a material containing aluminium as a main component and a resist material (105) is coated on the surface on said wiring material, wherein said method contains a step of selectively etching said wiring material with an alkaline aqueous solution, characterized in that said solution is selected from the group consisting of KOH, NaOH and ethylenediamine for patterning in a desired pattern and said resist layer is a negative photoresist layer which does not substantially dissolve in said alkaline aqueous solution.

2. A method of producing a thin film resistor, in which the thin film resistor has a wiring material (104) formed on a

heating resistor material (102), in which said wiring material is a material containing aluminium as a main component and a resist material (106) is coated on the surface on said wiring material, characterized in that said method contains a step of first half etching said wiring material with an acidic aqueous solution and thereafter selectively etching said wiring material with an alkaline aqueous solution of tetramethylammonium hydroxide for patterning in a desired pattern and that said resist layer is a positive photoresist layer which does not substantially dissolve in said alkaline aqueous solution.

3. A method according to Claim 1 or 2, wherein said resistor material comprises a material containing at least one selected from the group consisting of hafnium, zirconium, nickel, gold, silver, iron, palladium, silicon, tantalum, niobium, cobalt, indium, hafnium boride, zirconium boride, tantalum nitride, tantalum aluminum, titanium, and alloys thereof.
4. A method according to any one of Claims 1 to 3, wherein said alkaline aqueous solution contains at least one of a surfactant and a pH controller.
5. A method according to any one of Claims 1 to 4, wherein said thin film resistor is a heating resistor element for a liquid jet head which ejects a liquid utilizing thermal energy.
6. A method according to Claim 3, wherein said tetramethylammonium hydroxide has a concentration of up to 3.5 %.
7. A method according to Claim 1 or 6, wherein said alkaline aqueous solution is a developer for a photoresist used in said step of patterning.
8. A method according to any one of claims 1 to 7, wherein the wiring material is formed in a film-forming apparatus comprising an anti-sticking means, a surface of which has a tongued-and-grooved pattern.
9. A method according to claim 8, wherein a pitch of the tongued-and-grooved pattern of the anti-sticking means ranges from 1 to 50 mm.
10. A method according to claim 8 or 9, wherein the wiring material is formed by sputtering or vapor deposition.
11. A method according to claim 8, wherein the tongued-and-grooved pattern has a sawtooth cross section.
12. A method according to claim 8, wherein the tongued-and-grooved pattern has a rectangular cross section.

#### Patentansprüche

1. Verfahren zur Herstellung eines Dünnschichtwiderstands, in dem ein Dünnschichtwiderstand ein auf einem Wärmewiderstandsmaterial (102) erzeugtes Drahtmaterial (104) aufweist, in dem das Drahtmaterial ein Material ist, das Aluminium als eine Hauptkomponente enthält, und in dem ein Widerstandsmaterial (105) auf der Oberfläche des Drahtmaterials aufgeschichtet ist, wobei das Verfahren einen selektiven Ätzschritt des Drahtmaterials mit einer alkalischen wässrigen Lösung enthält,  
**dadurch gekennzeichnet, dass**  
die Lösung zur Musterbildung in einem gewünschten Muster aus der aus KOH, NaOH und Ethylendiamin bestehenden Gruppe ausgewählt ist und die Widerstandsschicht eine Schicht eines negativen Photoresists darstellt, die sich nicht wesentlich in der alkalischen wässrigen Lösung löst.
2. Verfahren zur Herstellung eines Dünnschichtwiderstands, in dem ein Dünnschichtwiderstand ein auf einem Wärmewiderstandsmaterial (102) erzeugtes Drahtmaterial (104) aufweist, in dem das Drahtmaterial ein Material ist, das Aluminium als eine Hauptkomponente enthält, und in dem ein Widerstandsmaterial (106) auf der Oberfläche des Drahtmaterials aufgeschichtet ist,  
**dadurch gekennzeichnet, dass**  
das Verfahren zuerst einen Ätzschritt des Drahtmaterials mit einer sauren wässrigen Lösung bis zur Hälfte und danach einen selektiven Ätzschritt des Drahtmaterials mit einer alkalischen wässrigen Lösung von Tetramethylammoniumhydroxid zur Musterbildung in einem gewünschten Muster enthält und dass die Widerstandsschicht eine Schicht eines positiven Photoresists darstellt, die sich nicht wesentlich in der alkalischen wässrigen Lösung löst.

## EP 0 603 782 B1

3. Verfahren gemäß Anspruch 1 oder 2, wobei das Widerstandsmaterial ein Material umfasst, das wenigstens ein Element enthält, das aus der folgenden Gruppe ausgewählt ist: Hafnium, Zirkonium, Nickel, Gold, Silber, Eisen, Palladium, Silicium, Tantal, Niob, Cobalt, Indium, Hafniumborid, Zirkoniumborid, Tantalnitrid, Tantal/Aluminium, Titan und Legierungen davon.

4. Verfahren gemäß irgendeinem der Ansprüche 1 bis 3, wobei die alkalische wässrige Lösung wenigstens ein oberflächenaktives Mittel und/oder pH-Einstellmittel enthält.

5. Verfahren gemäß irgendeinem der Ansprüche 1 bis 4, wobei der Dünnschichtwiderstand ein Heizwiderstandselement für einen Flüssigkeitsstrahlkopf darstellt, der eine Flüssigkeit unter Nutzung von Wärmeenergie ausstößt.

6. Verfahren gemäß Anspruch 3, wobei Tetramethylammoniumhydroxid eine Konzentration von bis zu 3,5 % aufweist.

7. Verfahren gemäß Anspruch 1 oder 6, wobei die alkalische wässrige Lösung ein Entwicklungsmittel für einen in dem Musterbildungsschritt eingesetzten Photoresist darstellt.

8. Verfahren gemäß irgendeinem der Ansprüche 1 bis 7, wobei das Drahtmaterial in einer Schichterzeugungsvorrichtung erzeugt wird, die eine Antihafteinrichtung umfasst, deren Oberfläche ein Nut-und-Feder-Muster aufweist.

9. Verfahren gemäß Anspruch 8, wobei der Abstand des Nut-und-Feder-Musters der Antihafteinrichtung in einem Bereich von 1 bis 50 mm liegt.

10. Verfahren gemäß Anspruch 8 oder 9, wobei das Drahtmaterial durch Sputtern oder Dampfabscheidung erzeugt wird.

11. Verfahren gemäß Anspruch 8, wobei das Nut-und-Feder-Muster einen Sägezahnquerschnitt aufweist.

12. Verfahren gemäß Anspruch 8, wobei das Nut-und-Feder-Muster einen rechtwinkligen Querschnitt aufweist.

### Revendications

1. Procédé de fabrication d'une résistance à couche mince, dans lequel la résistance à couche mince comporte une matière (104) de câblage formée sur une matière (102) de résistance chauffante, dans lequel ladite matière de câblage est une matière contenant de l'aluminium comme composant principal, et dans lequel une matière (105) formant résist est déposée sur la surface de ladite matière de câblage, ledit procédé comportant une étape d'attaque de manière sélective de ladite matière de câblage à l'aide d'une solution aqueuse alcaline, caractérisé en ce que ladite solution est choisie dans le groupe constitué de KOH, de NaOH et d'éthylènediamine pour formation de motif suivant un motif voulu, et en ce que ladite couche de résist est une couche de photorésist négatif qui ne se dissout sensiblement pas dans ladite solution aqueuse alcaline.

2. Procédé de fabrication d'une résistance à couche mince, dans lequel la résistance à couche mince comporte une matière (104) de câblage formée sur une matière (102) de résistance chauffante, dans lequel ladite matière de câblage est une matière contenant de l'aluminium comme composant principal, et dans lequel une matière (106) formant résist est déposée sur la surface de ladite matière de câblage, caractérisé en ce que ledit procédé contient une étape consistant à attaquer d'abord à demi ladite matière de câblage avec une solution aqueuse acide, et à attaquer ensuite sélectivement ladite matière de câblage avec une solution aqueuse alcaline d'hydroxyde de tétraméthylammonium pour formation de motif suivant un motif voulu, et en ce que ladite couche de résist est une couche de photorésist positif qui ne se dissout sensiblement pas dans ladite solution aqueuse alcaline.

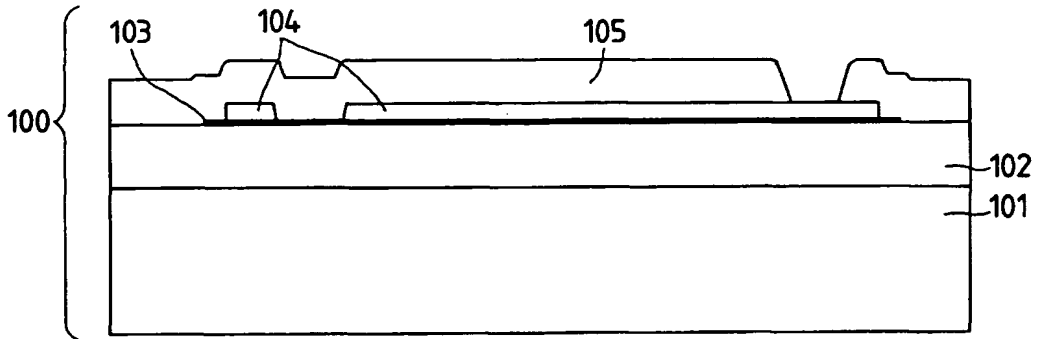
3. Procédé selon la revendication 1 ou 2, dans lequel ladite matière de résistance comprend une matière contenant au moins l'une choisie dans le groupe constitué d'hafnium, de zirkonium, de nickel, d'or, d'argent, de fer, de palladium, de silicium, de tantale, de niobium, de cobalt, d'indium, de borure d'hafnium, de borure de zirkonium, de nitrure de tantale, d'aluminium au tantale, de titane, et de leurs alliages.

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel ladite solution aqueuse alcaline contient au moins un agent tensioactif et un régulateur du pH.

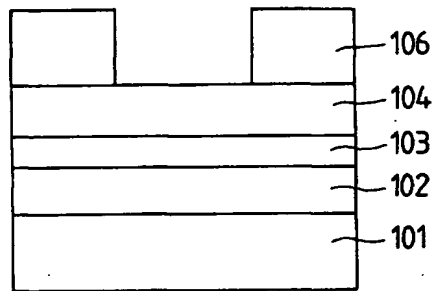
## EP 0 603 782 B1

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel ladite résistance à couche mince est un élément de résistance chauffante pour une tête à jet de liquide qui éjecte un liquide en utilisant de l'énergie thermique.
- 5 6. Procédé selon la revendication 3, dans lequel ledit hydroxyde de tétraméthylammonium a une concentration allant jusqu'à 3,5 %.
7. Procédé selon la revendication 1 ou 6, dans lequel ladite solution aqueuse alcaline est un révélateur pour un photorésist utilisé dans ladite étape de formation de motif.
- 10 8. Procédé selon l'une quelconque des revendications 1 à 7, dans lequel la matière de câblage est formée dans un appareil de formation de film comprenant un moyen antiadhésif, dont une surface comporte un motif à rainures et languettes.
- 15 9. Procédé selon la revendication 8, dans lequel le pas du motif à rainures et languettes du moyen antiadhésif va de 1 à 50 mm.
10. Procédé selon la revendication 8 ou 9, dans lequel la matière de câblage est formée par pulvérisation cathodique ou dépôt en phase vapeur.
- 20 11. Procédé selon la revendication 8, dans lequel le motif à rainures et languettes a une section transversale en dents de scie.
- 25 12. Procédé selon la revendication 8, dans lequel le motif à rainures et languettes a une section transversale rectangulaire.

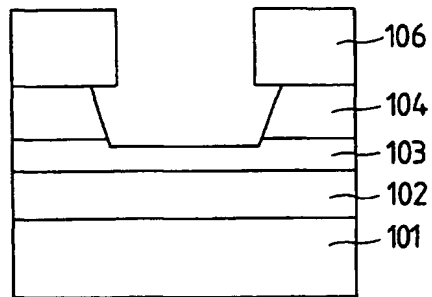
*FIG. 1 PRIOR ART*



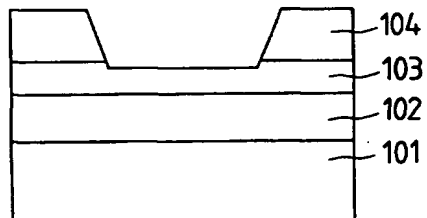
*FIG. 2A*



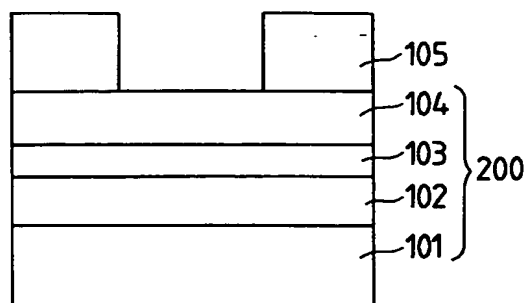
*FIG. 2B*



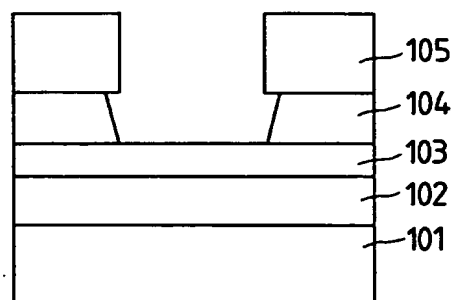
*FIG. 2C*



*FIG. 3A*



*FIG. 3B*



*FIG. 3C*

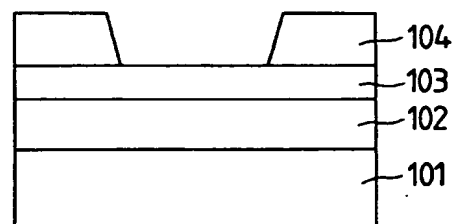


FIG. 4A

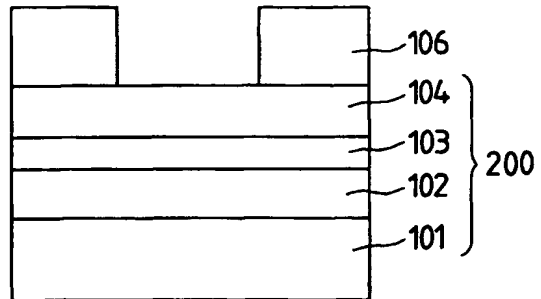


FIG. 4B

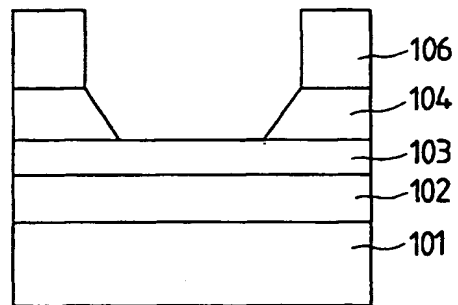


FIG. 4C

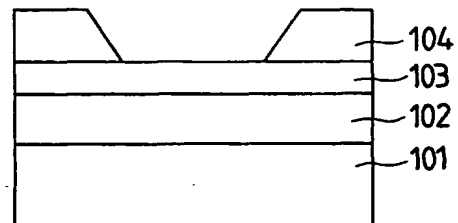


FIG. 5A

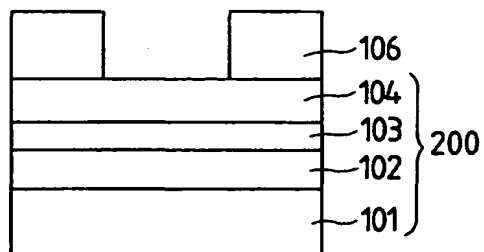


FIG. 5B

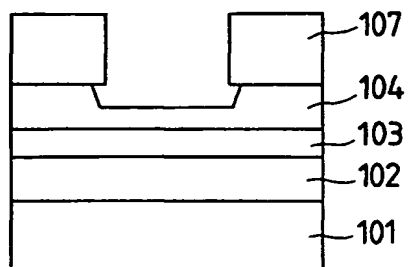


FIG. 5C

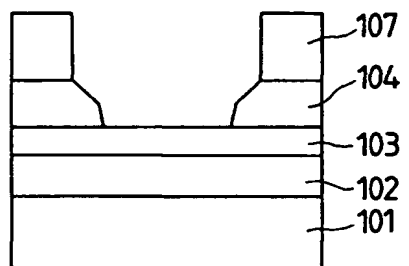


FIG. 5D

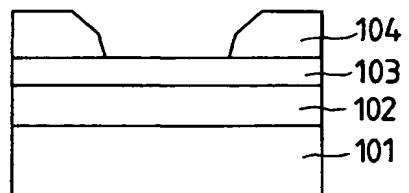




FIG. 6

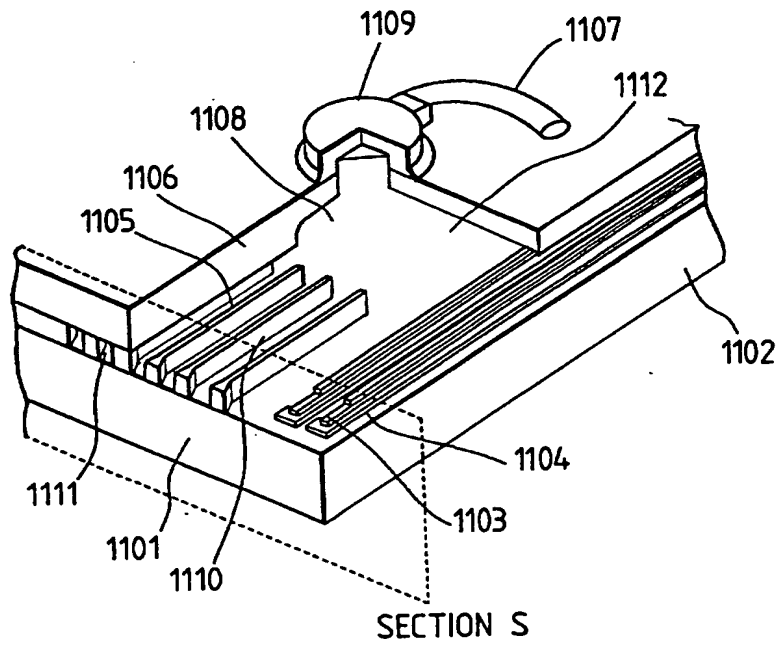


FIG. 9

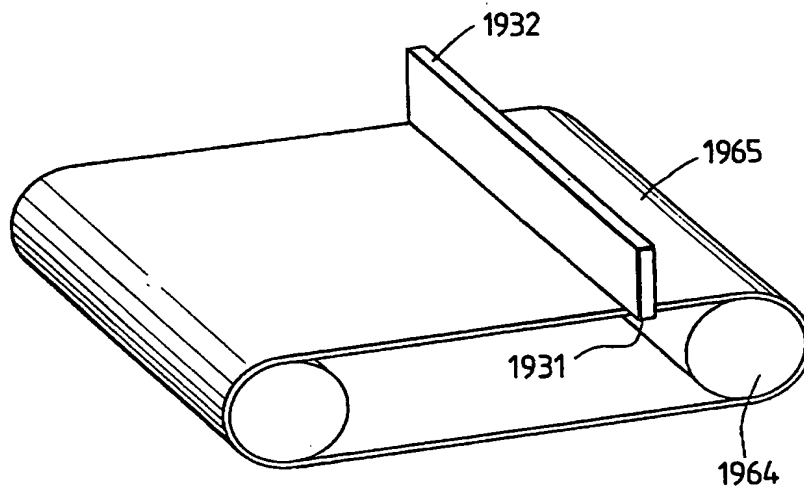
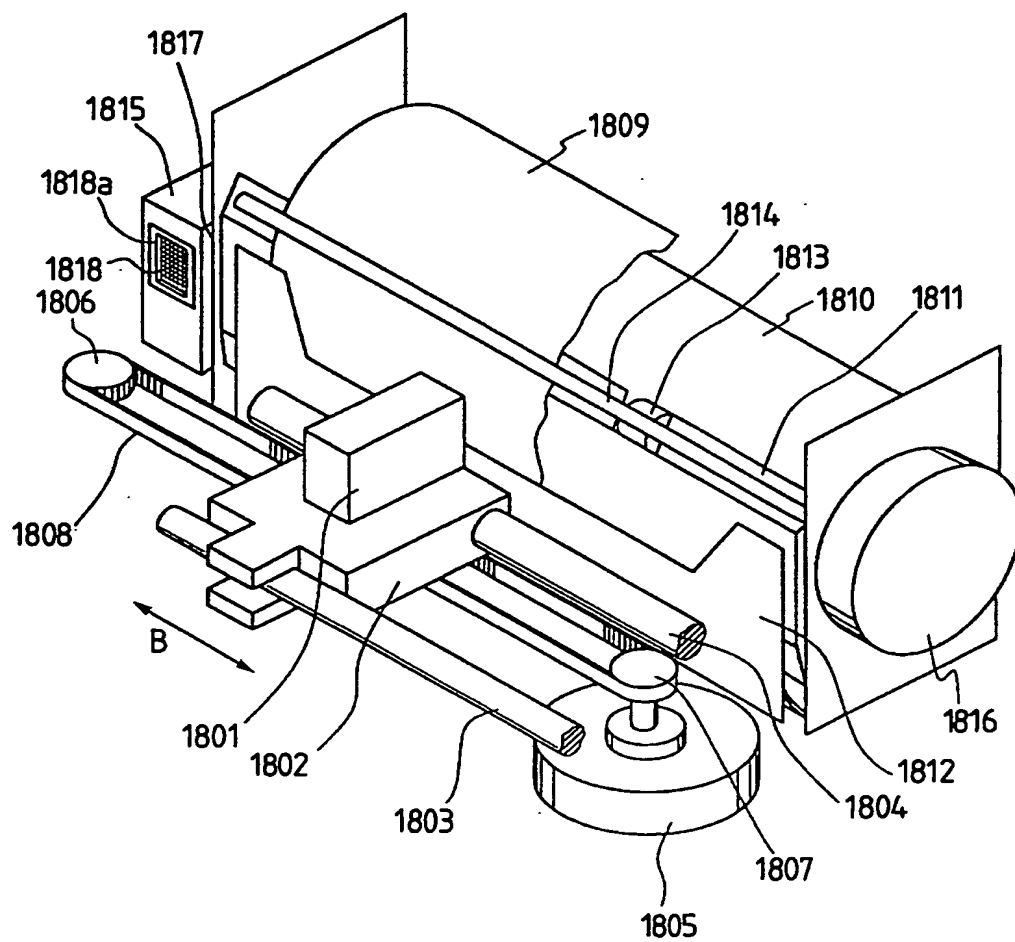
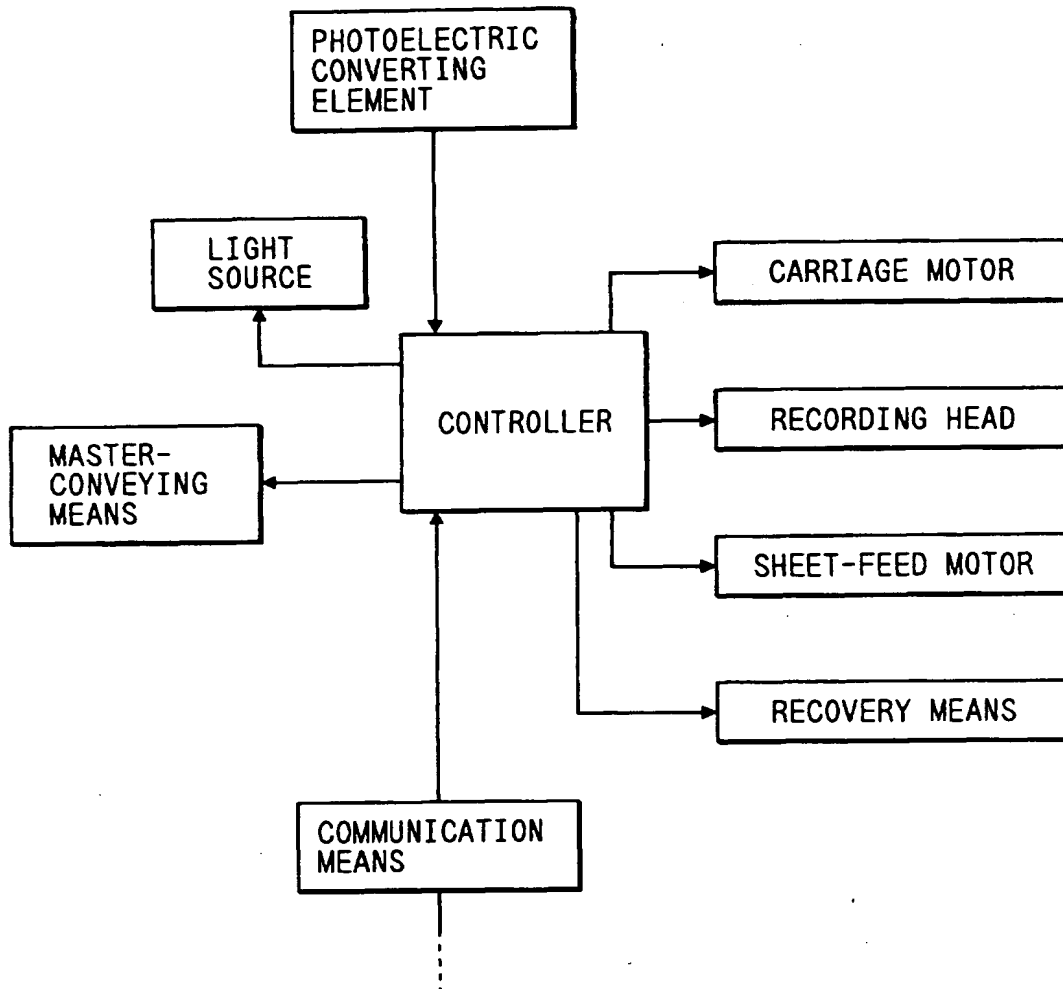
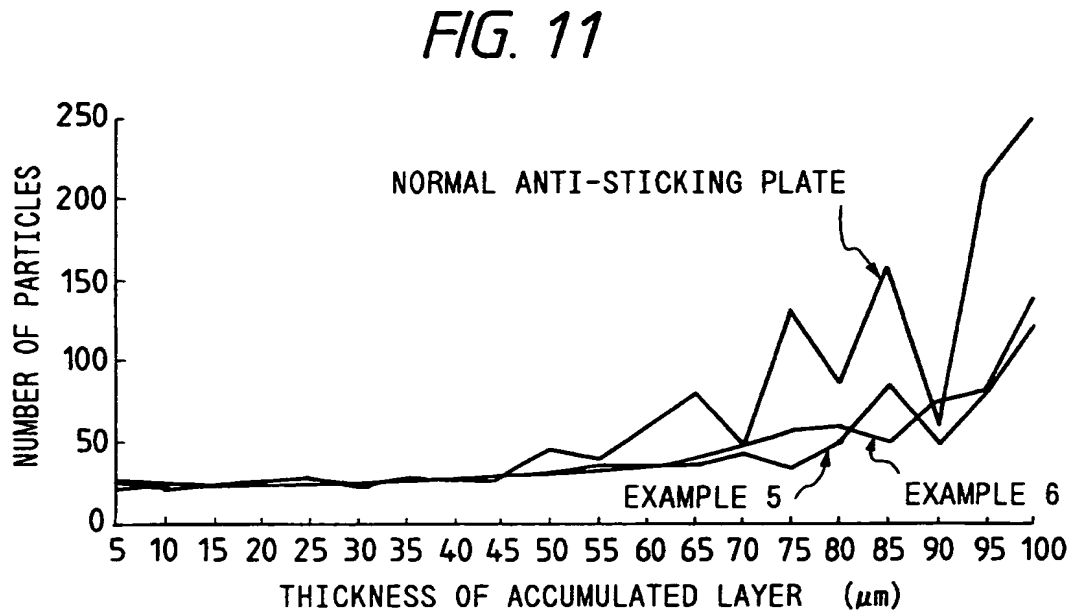
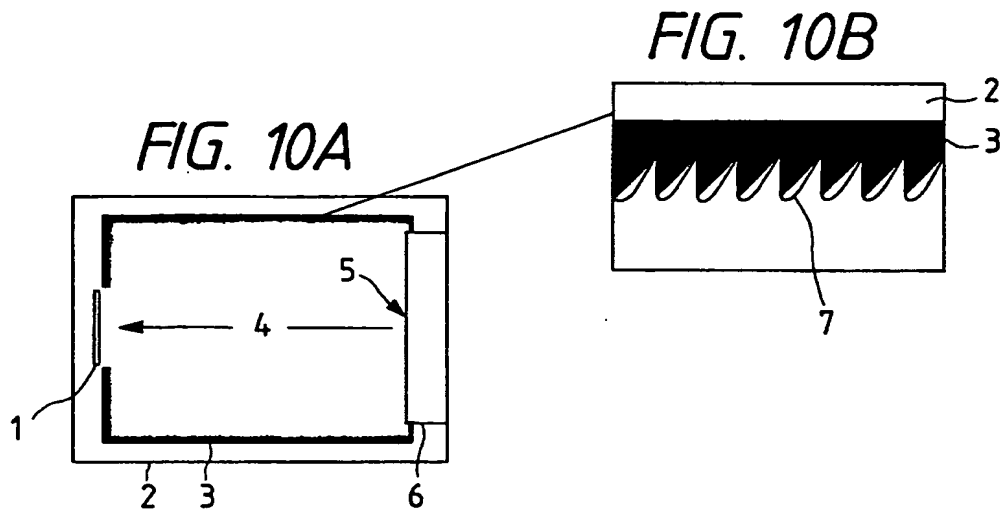


FIG. 7



*FIG. 8*





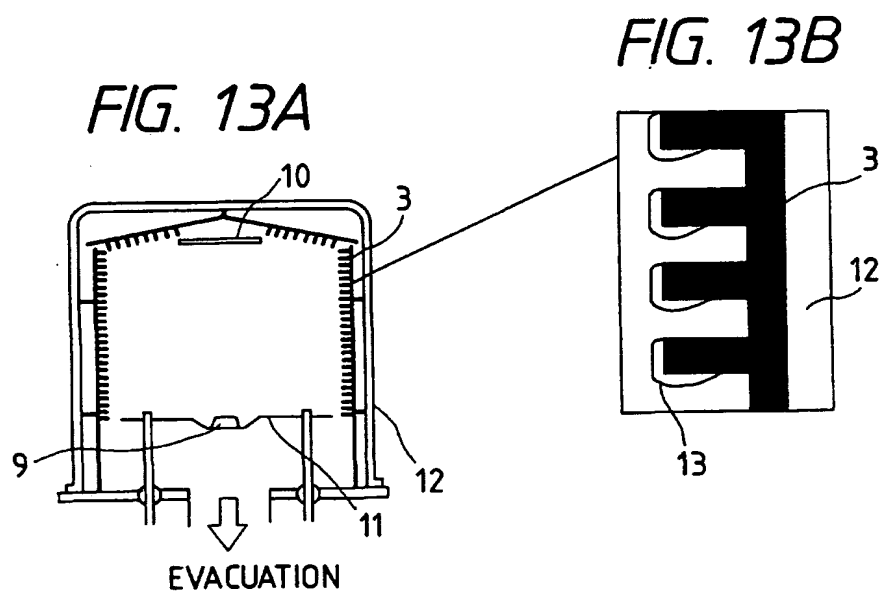
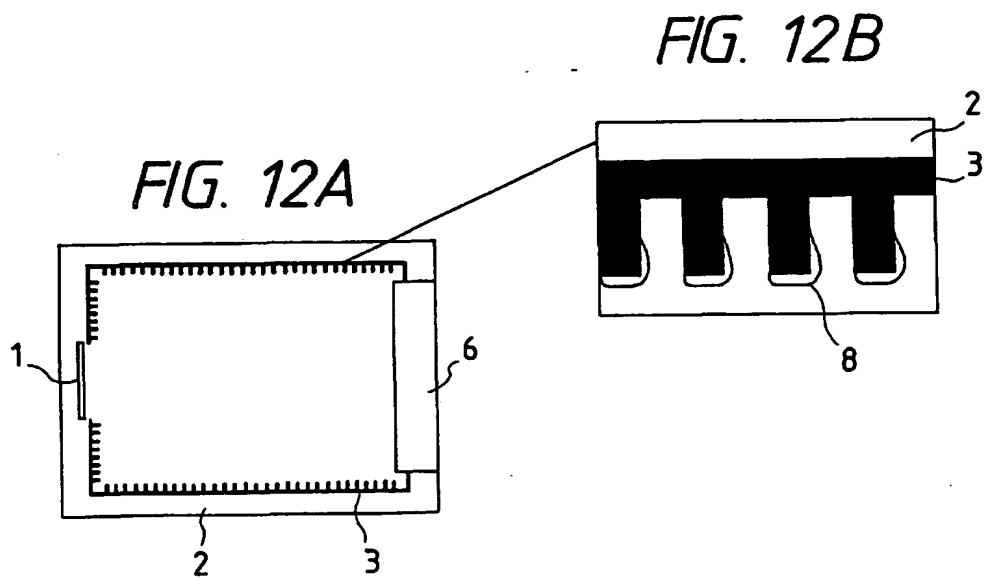


FIG. 14

